Strait of Georgia Juvenile Herring Survey, September and October 2009

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STRAIT OF GEORGIA JUVENILE HERRING SURVEY, SEPTEMBER AND OCTOBER 2009

by

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ABSTRACT

Thompson, M., Fort, C., and Schweigert, J. 2010. Strait of Georgia juvenile herring survey, September and October 2009. Can. Manuscr. Rep. Fish. Aquat. Sci. 2921: v + 29 p.

A survey of juvenile herring was conducted in the Strait of Georgia during late September and early October 2009. Forty-eight stations were sampled throughout the Strait of Georgia following the ten core transects that have been sampled since 1990. The survey area extends from Trincomali Channel in the south to Smelt Bay in the north. Plankton tows were performed to determine food organism abundance in the study area.

RESUME

Thompson, M., Fort, C., and Schweigert, J. 2010. Strait of Georgia juvenile herring survey, September and October 2009. Can. Manuscr. Rep. Fish. Aquat. Sci. 2921: v + 29 p.

Une campagne de relevés portant sur les stocks de harengs juvéniles du détroit de Georgia a été effectuée fin septembre-début octobre 2009. Des échantillons ont été prélevés dans 48 stations du détroit de Georgia situées sur les dix transects échantillonnés depuis 1990. La zone d'échantillonnage s'étendait du chenal Trincomali au sud à la baie de Smelt au nord. Des traits de plancton ont été effectués pour déterminer l'abondance de nourriture disponible dans la zone étudiée.

INTRODUCTION

Pacific herring (*Clupea pallasi*) are an important commercial and a vital forage species for many marine mammals, birds and other fish in British Columbia's coastal waters. Herring spawn principally on marine vegetation in the subtidal and upper intertidal zone between February and June, with peak spawning between March and April (Humphreys and Hourston 1978). Larvae hatch in two to three weeks, and disperse with surface currents, metamorphosing into juvenile or young-of-the-year herring at a length of ~25mm (Hourston and Haegele 1980). Herring are considered juveniles or immature until they are about three years of age and have joined the sexually mature spawning population (Hay and McCarter 1999). During daylight hours, juvenile herring congregate in schools, occasionally forming mixed aggregates with other pelagic species, close to shore near the bottom (Haegele 1997). At dusk, these fish migrate into surface waters to feed on plankton. During this time they are vulnerable to purse seine gear.

Purse seine surveys to determine the distribution and abundance of juvenile herring in the Strait of Georgia have been conducted annually since 1990, except for 1995 (Figure 1). The main objective of the survey was to estimate the density and relative abundance of the juvenile herring population as a potential indicator of recruitment before they have joined the spawning stock (Schweigert et. al. 2009). In addition to recruitment prediction, the surveys have contributed to a better understanding of the distribution, abundance, and ecological role of herring in the Strait of Georgia.

METHODS

The annual survey of juvenile herring in the Strait of Georgia in 2009 (Figure 2) followed the ten core sampling transects (1 – 6, 8 – 11); which are made up of 48 sampling stations and have been sampled consistently since 1990 (except 1995). These ten core transects have been used in juvenile herring recruitment prediction (Hay et. al. 2003). Originally, the sampling sites were chosen based on known historical herring spawning sites, and represent both nearshore and open water habitats (Haegele et. al. 2005). In 2009, sampling was conducted from September 14th to October 1st (Table 1). All 48 core stations were sampled.

Fish Sampling

The 12 m, aluminum-hulled Fisheries Research Vessel *Walker Rock* was used for all fishing events. A 183 m long and 27 m deep purse seine net of knotless web, resulting in an area fished of ~2665 m^2, was used for all fishing events. The body of the net had 46 m of 22.2 mm mesh at the tow end followed by 91 m of 19.0 mm mesh, and the bunt end was 46 m of 9.5 mm mesh. The net fished to a depth of 10 m, and was able to retain fish greater than 20 mm in length. All sets were made after dusk when herring are feeding near the surface. All sets were made "blind" at the pre-determined sampling stations.

Five sets were completed per night, depending on location, and length of travel between transects and the marine weather forecast. For most sets, it was possible to land the entire catch for biological sampling. On occasion, it was not practical to land a large set in its entirety, so sub-sampling was necessary. When sub-sampling was required, a 40 kg tote was filled with randomly selected fish and retained for biological sampling. Several dipnet samples were taken from various parts of the net (catch) to make up the random sub-sample. The remainder of the set was released over the corkline, its size estimated as the number of totes released. The number of herring caught in each set was determined by dividing the total catch weight by the mean weight of sub-sampled herring. The number of other species caught was determined in the same manner (Tables 3 and 4). All fish retained for sampling were bagged and preserved in a 3.7 % seawater formalin solution, with the exception of large predator species (e.g. adult salmon and flatfish). These fish were individually measured in the field. All retained fish were later sampled in the laboratory at the Pacific Biological Station. From each set, 100 or more herring and all other fish species caught were identified, weighed and measured. If the set contained less than 100 herring, then all herring were weighed and measured. Consistent with standard practices, herring were measured to standard length, salmon to fork length and groundfish to total length; all to the nearest millimeter. All other fish species were measured to standard length.

Plankton Sampling

Twenty stepped oblique plankton tows were performed during the survey (Figures 3). The tows always were completed after dusk and immediately before the fishing events. A nearshore and offshore tow location was sampled for all transects. Dual 19 cm diameter bongo nets with 350 µm mesh were used for sampling, resulting in 'left' and 'right' bongo plankton samples (only left samples were processed). The bongos were lowered to 20 m (10 m in shallow areas) and raised by an electric winch at a rate of 1 m every 15 sec (or 1 m every 30 sec for shallow areas). A General Oceanics® 2030R model flowmeter was attached to the left bongo to determine the volume of seawater filtered. Volume filtered was calculated using the following equation (McCarter and Hay 2002):

$$\mathbf{V = (A \cdot F \cdot K) / 999{,}999}$$

where:

V = volume of water filtered through the plankton net (m^3)
A = area of net opening (0.02835 m^2)
F = number of revolutions recorded by the flow meter (m)
K = standard speed rotor constant for 7cm rotor (26,873)

Upon retrieval, the bongo nets were washed with a high pressure deck hose, and the samples preserved in 3.7 % seawater formalin.

In the laboratory, a volumetric splitter was used to reduce the sample size to a point where organisms could be conveniently counted and identified in a counting tray using a

stereo microscope under 30X magnification. Sample splitting continued until a target size of roughly 300 organisms was reached (Thompson et al. 2003).

When possible, plankters were identified to the lowest taxonomic level. Copepods were identified to species. Densities for all plankters were determined and expressed as plankters/ m^3.

RESULTS

Herring

Forty-eight stations were sampled from transects 1 – 6, 8 – 11. A total of 2672 herring were weighed and measured resulting in a length frequency distribution that was distinctly unimodal for age-0+ herring (Figure 4). Three length designations for the juvenile herring age-classes were produced:

0+ = herring less than or equal to 110 mm standard length
1+ = herring between 111 mm and 148 mm standard length
2+ and older = herring greater than or equal to 149 mm standard length

Age-0+ herring occurred in 83.3 % of the stations (Table 3). Forty of the forty-eight stations contained age-0+ herring. The mean length and weight for age-0+ herring was 91 mm and 9.75 g respectively. A total of 26645 age-0+ were caught for a total weight of 262.73 kg (Table 4).

Age-1+ herring occurred in 20.8 % of the stations (Table 3). Only ten of the forty-eight stations sampled contained age-1+ herring. The mean length and weight for age-1+ herring was 133 mm and 31.69 g, respectively. A total of 1107 age-1+ herring were caught for a total weight of 42.7 kg (Table 4).

Age-2+ herring occurred in only one station and consisted of a single fish.

Length frequency histograms by transect location for all sampled herring are shown in Figure 5. Most transects were dominated by a single age-0+ age-class except Clarke Rock (Transect 1) and Atrevida Reef (Transect 9) which included some age-1+ herring. A length-weight relationship for all sampled herring from the survey showed a positive correlation coefficient (r^2) of 0.9724 (Figure 6).

Plankton

There were 25 categories of organisms identified in 20 plankton samples (Tables 5 and 6). An average of 13.215 m^3 of water was filtered per plankton tow. Low volumes were recorded on Bowser (transect 3 station 1) and Henry Bay (transect 4 stations 1 and 3) most likely due to heavy algae blooms in the area. *Paracalanus parvus* copepods were the only category to occur in all samples. Calanoid copepod *Paracalanus parvus*,

cyclopoid copepod *Corycaeus anglicus*, shrimp larvae and medusae (*Aequora victoria*) occurred in >90% of the samples. More than 66% of all plankton biomass captured were calanoid copepod *Paracalanus parvus*, larvaceans (*Oikopleura sp.* and *Frittillaria sp.*), barnacle larvae and cladocerans (*Podon sp.* and *Evadne sp.*).

CONCLUSION

Forty-eight stations were sampled resulting in 20 different fish species recorded from purse seine sets. A total of 2672 herring were measured and weighed creating a unimodal histogram clearly representing age-0+ juvenile herring. Twenty plankton tows were performed resulting in calanoid copepod *Paracalanus parvus* and cladocerans (*Podon sp.* and *Evadne sp.*) being the predominant organisms in numbers and biomass.

ACKNOWLEDGMENTS

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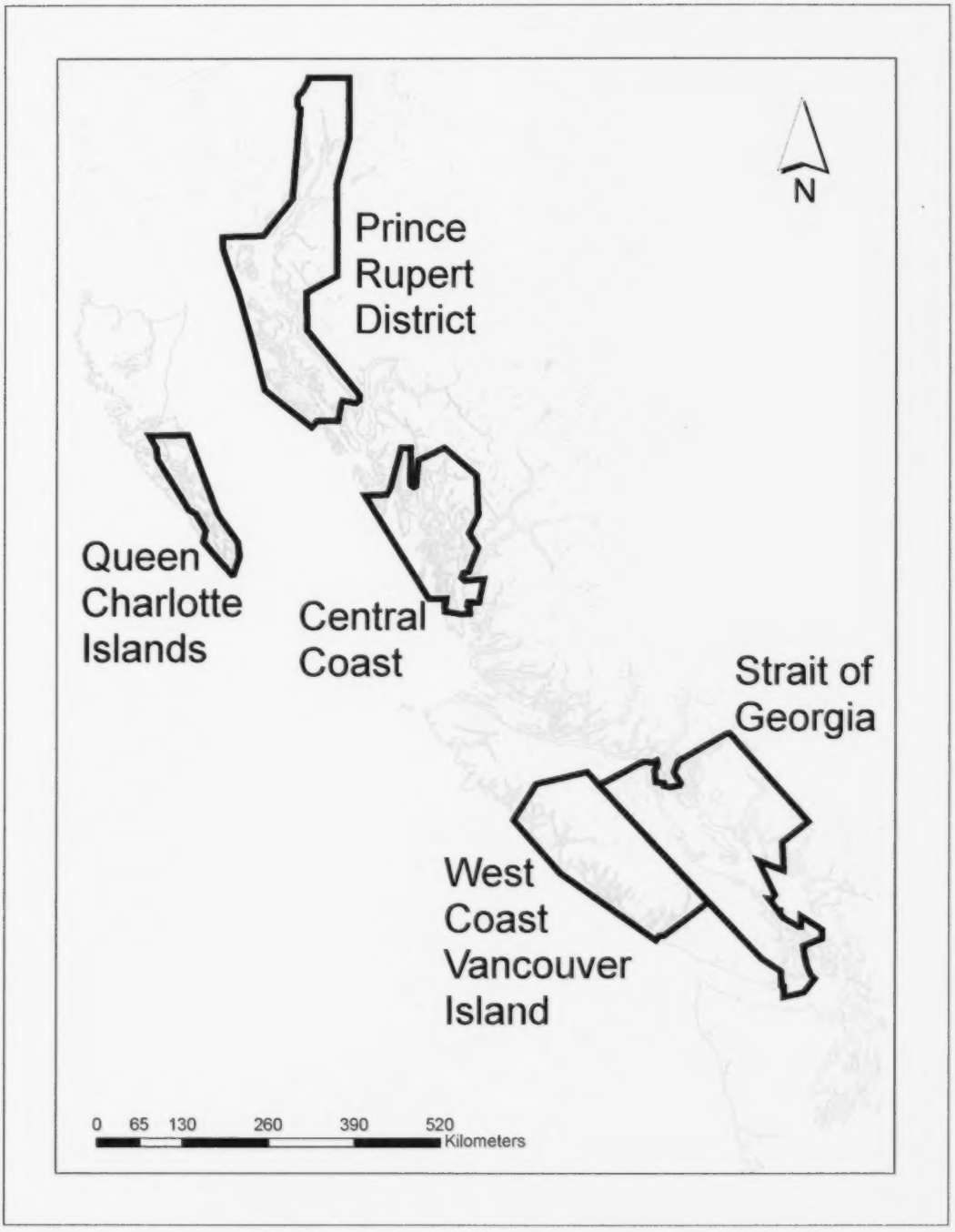


Figure 1. The five major British Columbia herring stock assessment areas.

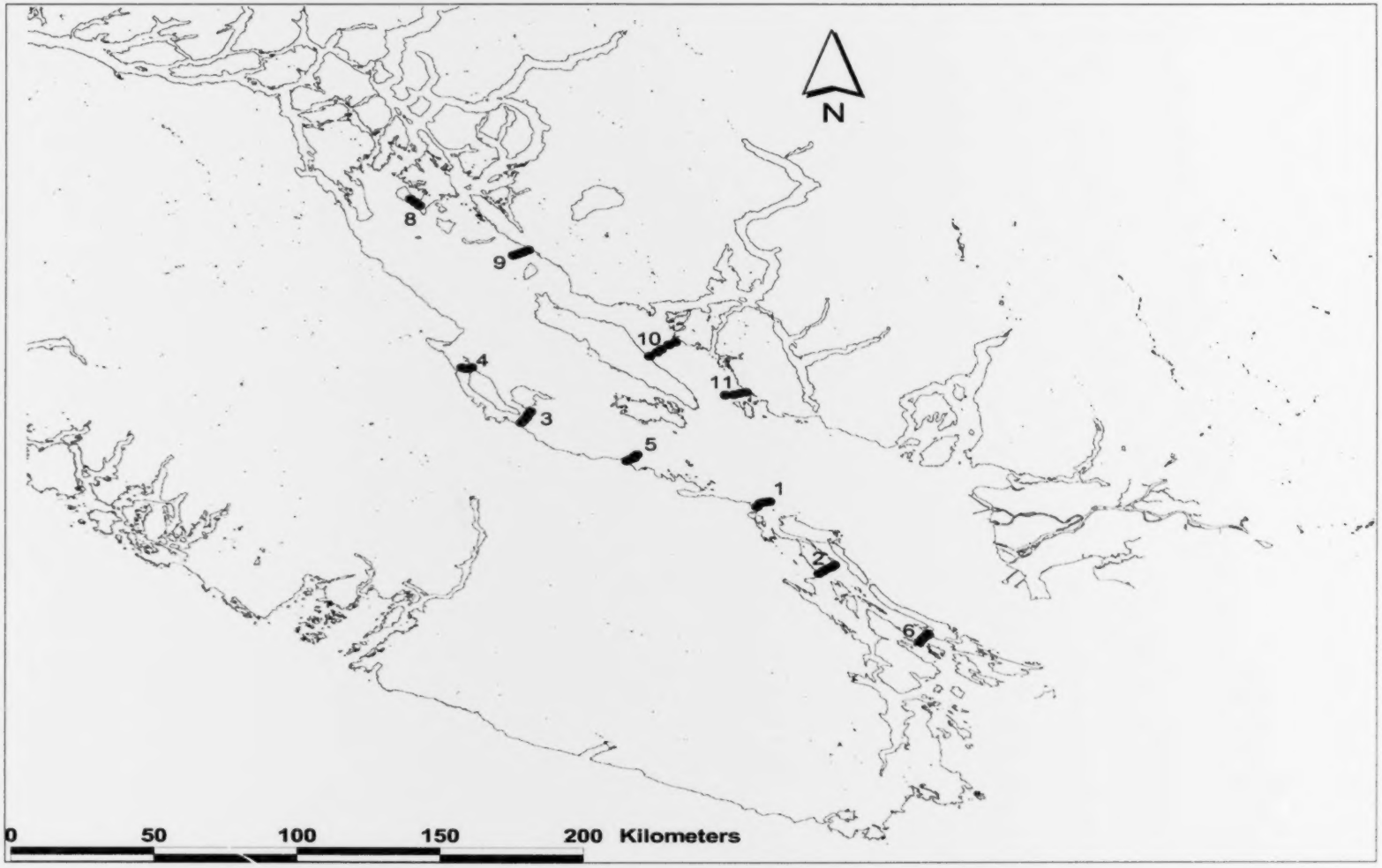


Figure 2. Purse seine set locations for the 2009 Strait of Georgia juvenile herring survey.

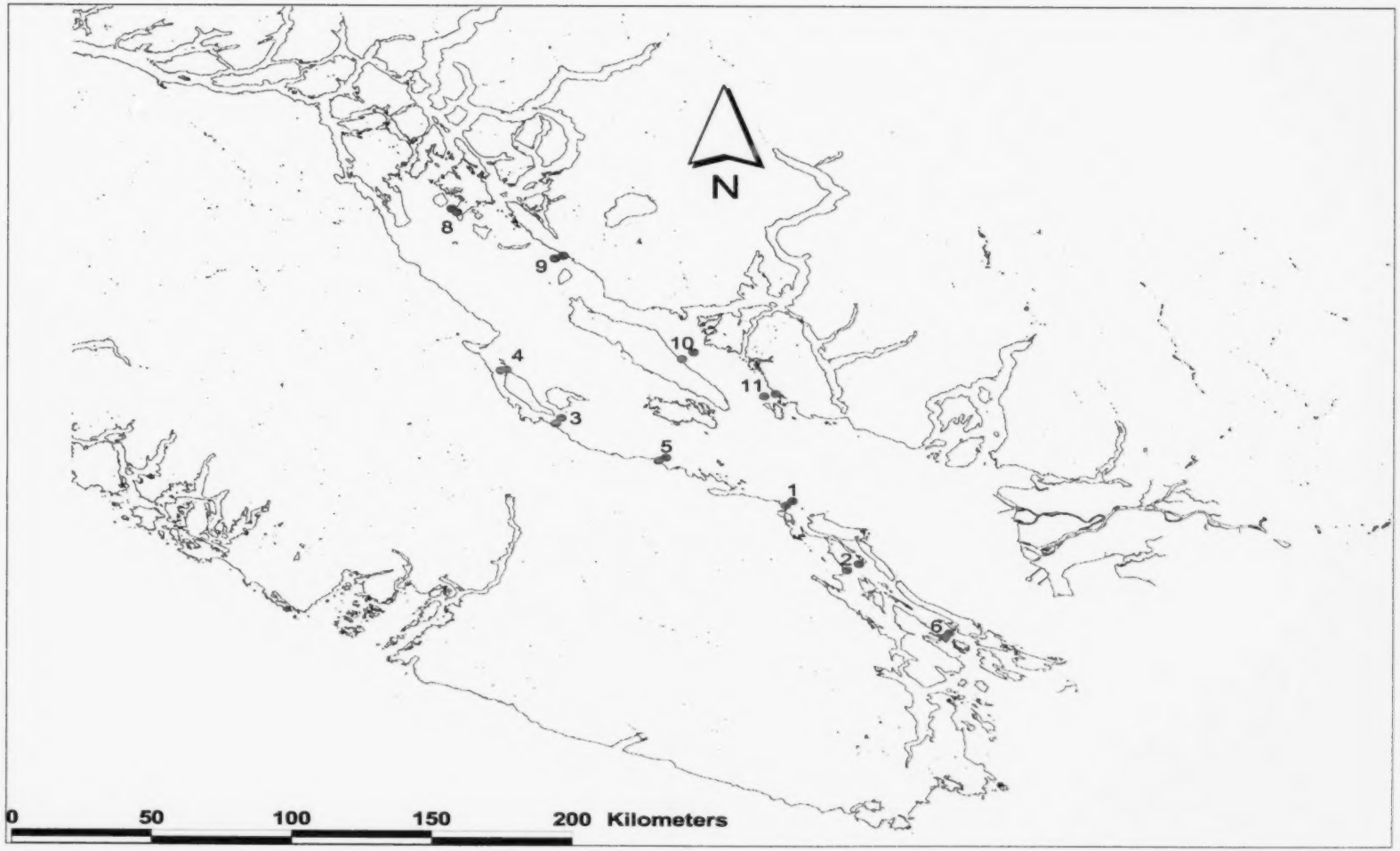


Figure 3. Plankton stations for the 2009 Strait of Georgia juvenile herring survey.

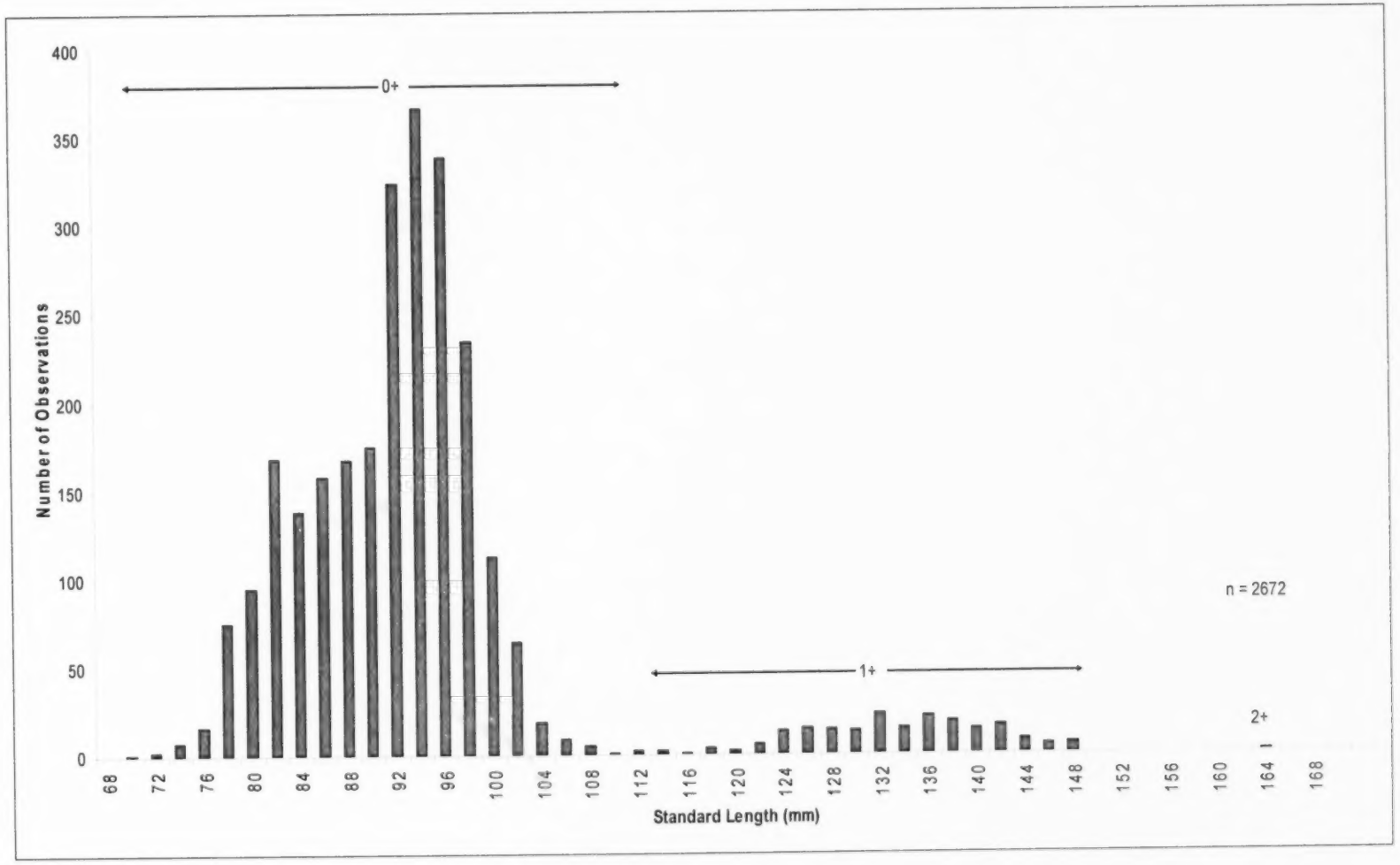


Figure 4. Length-frequency distribution for all herring sampled during the 2009 Strait of Georgia juvenile herring survey.

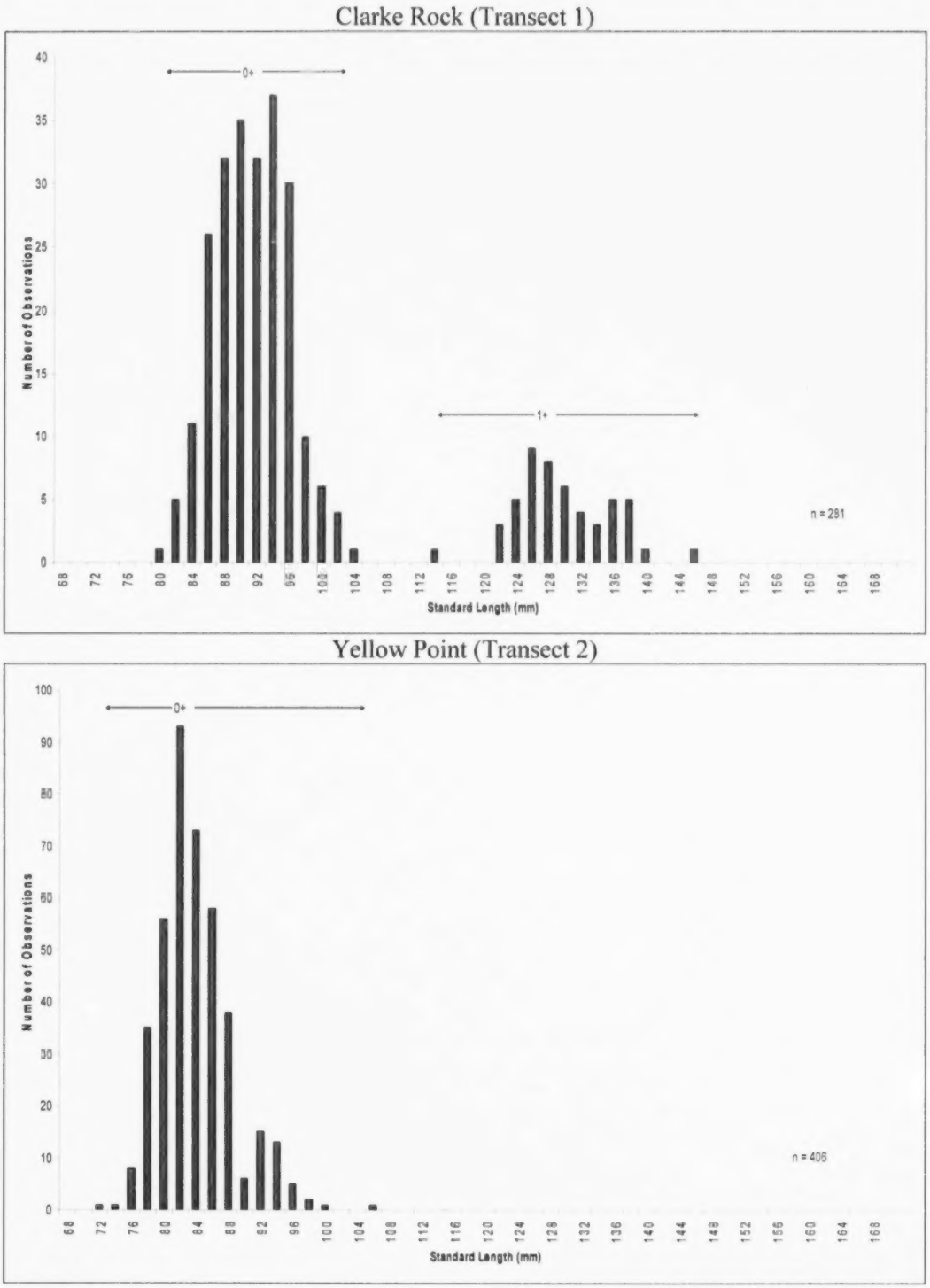
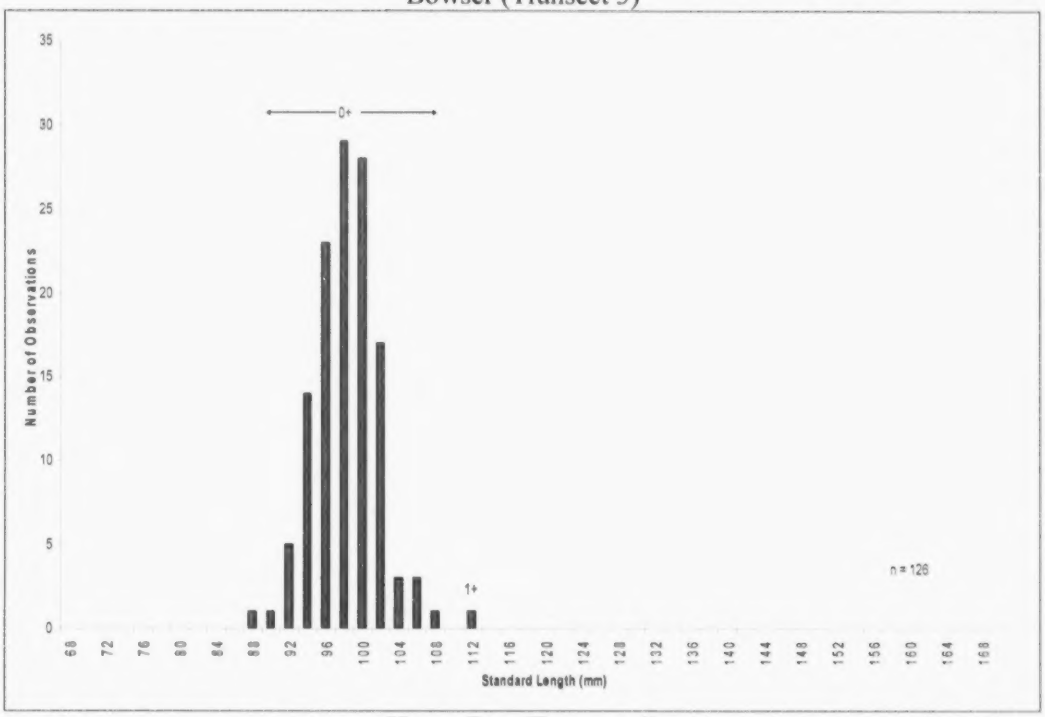


Figure 5. Length-frequency histograms of juvenile herring by transect location for the 2009 Strait of Georgia survey.

Bowser (Transect 3)



Henry Bay (Transect 4)

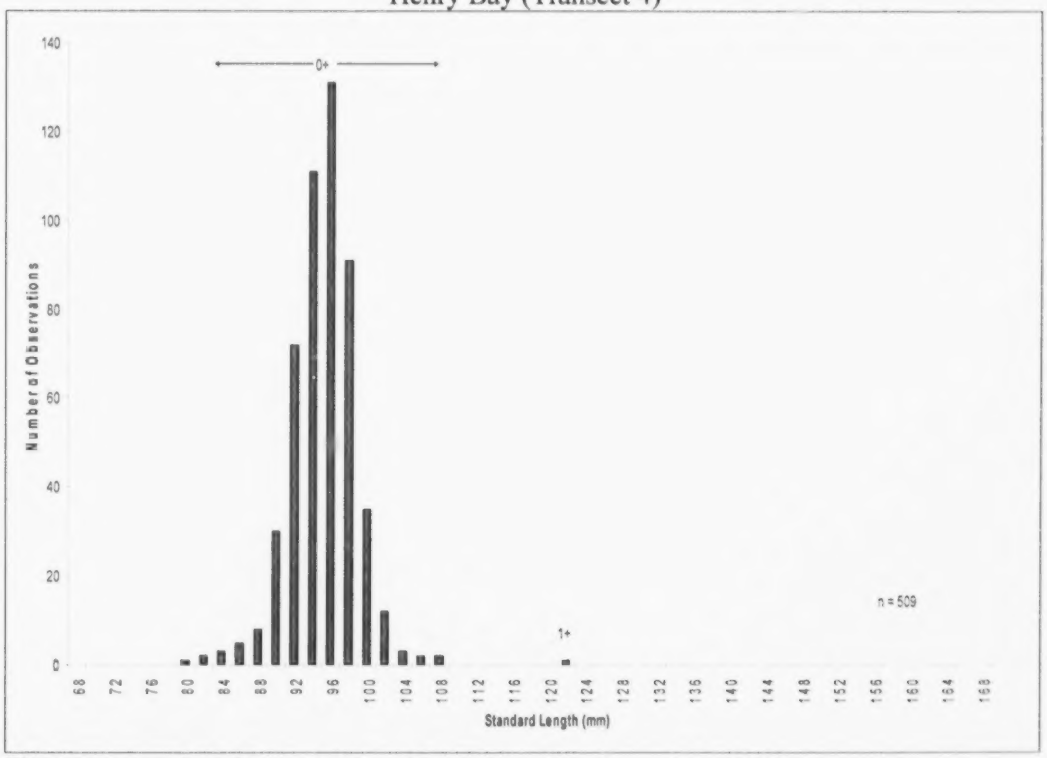
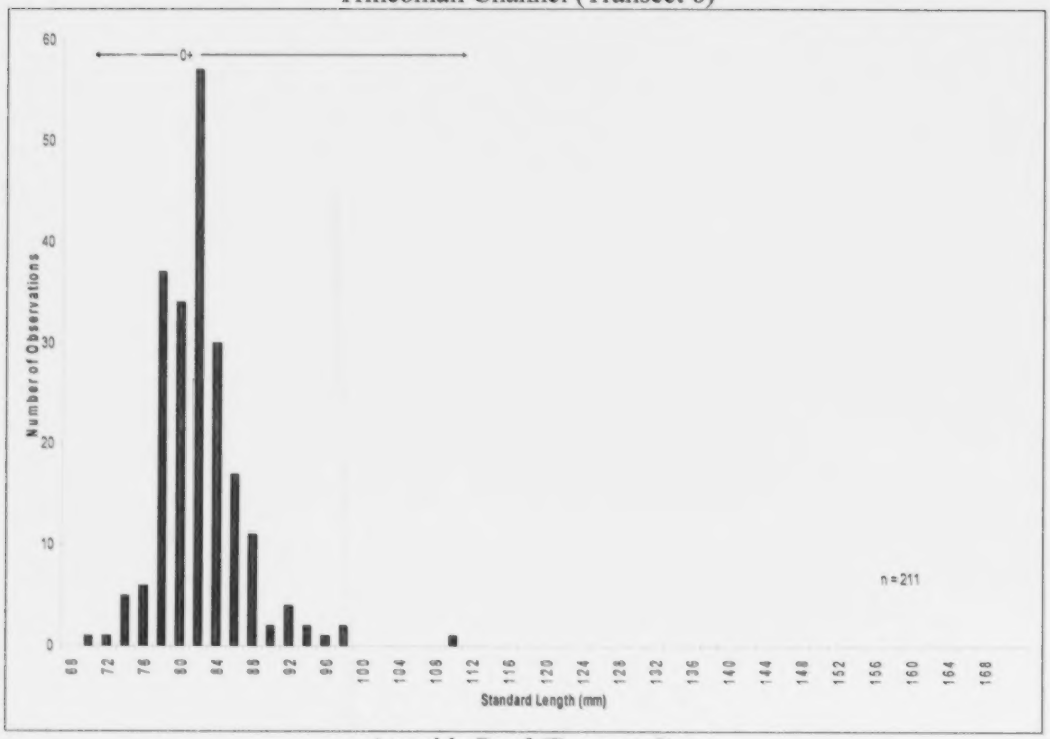


Figure 5…continued

Trincomali Channel (Transect 6)



Atrevida Reef (Transect 9)

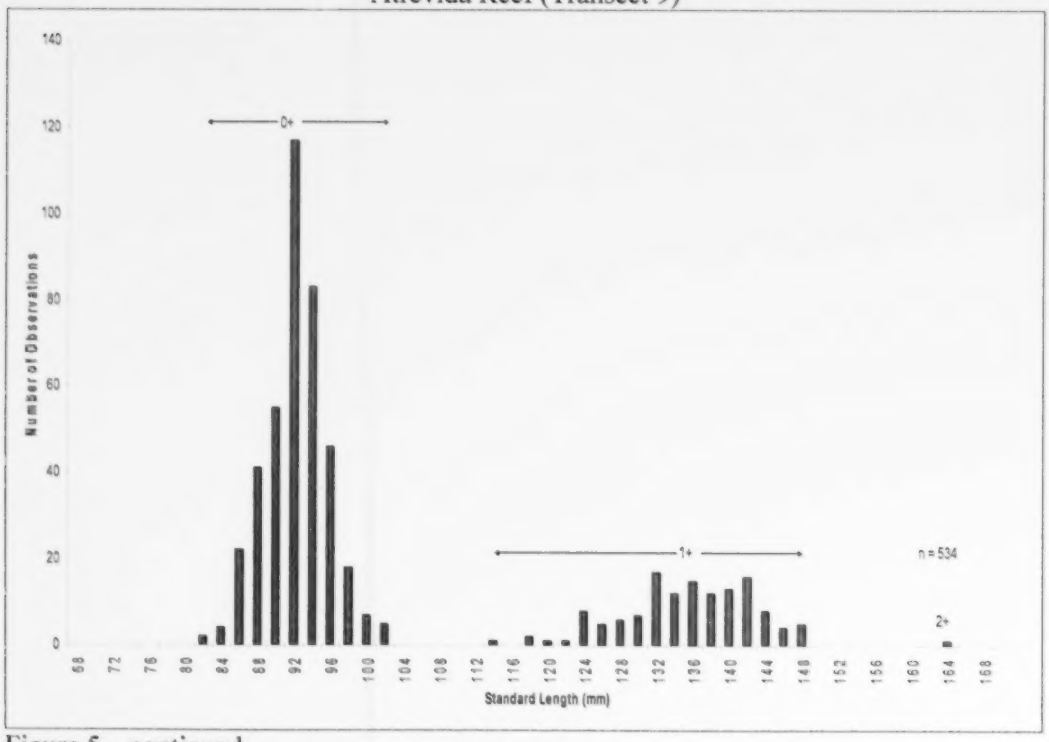
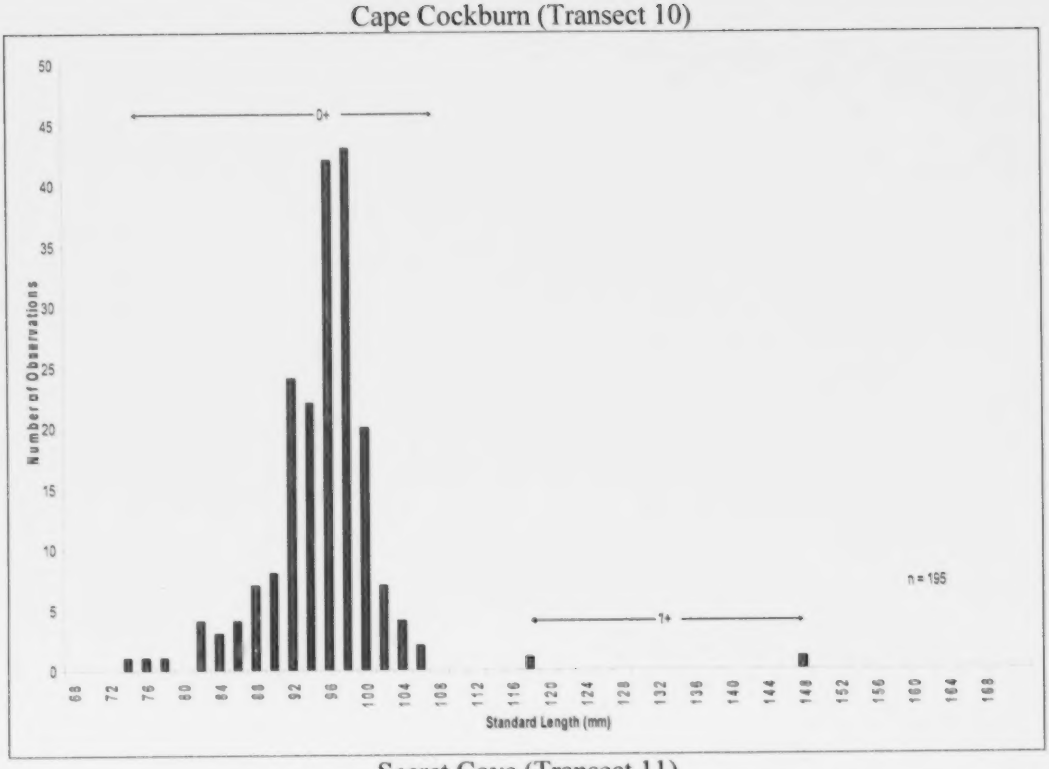


Figure 5…continued

Cape Cockburn (Transect 10)



Secret Cove (Transect 11)

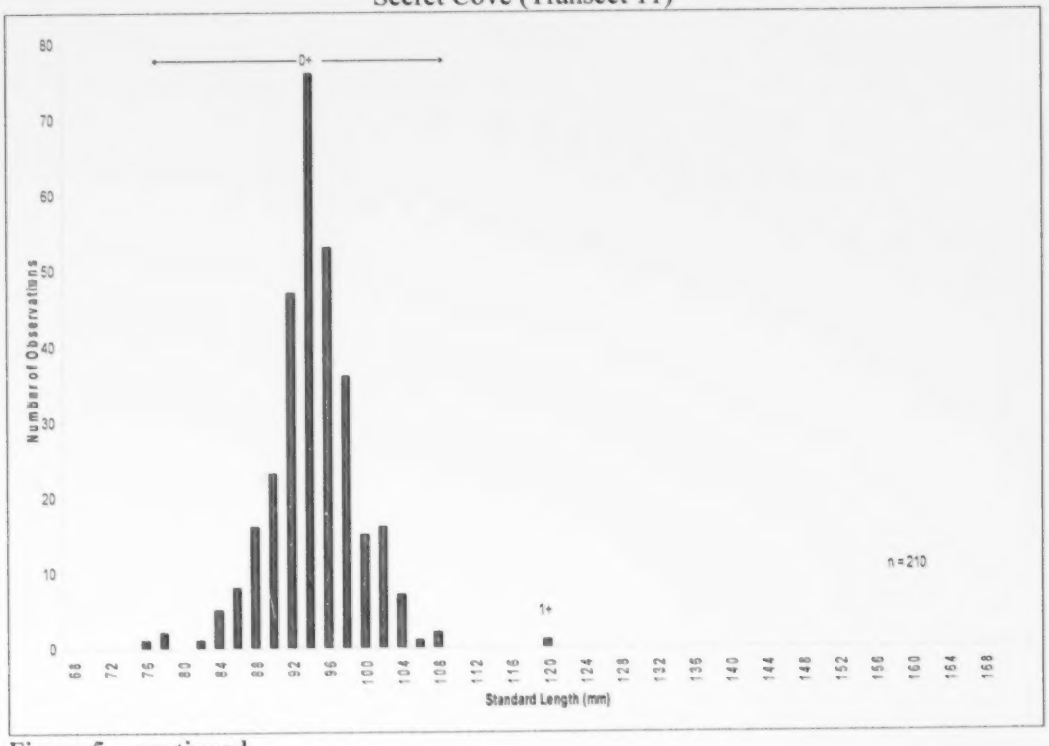


Figure 5…continued

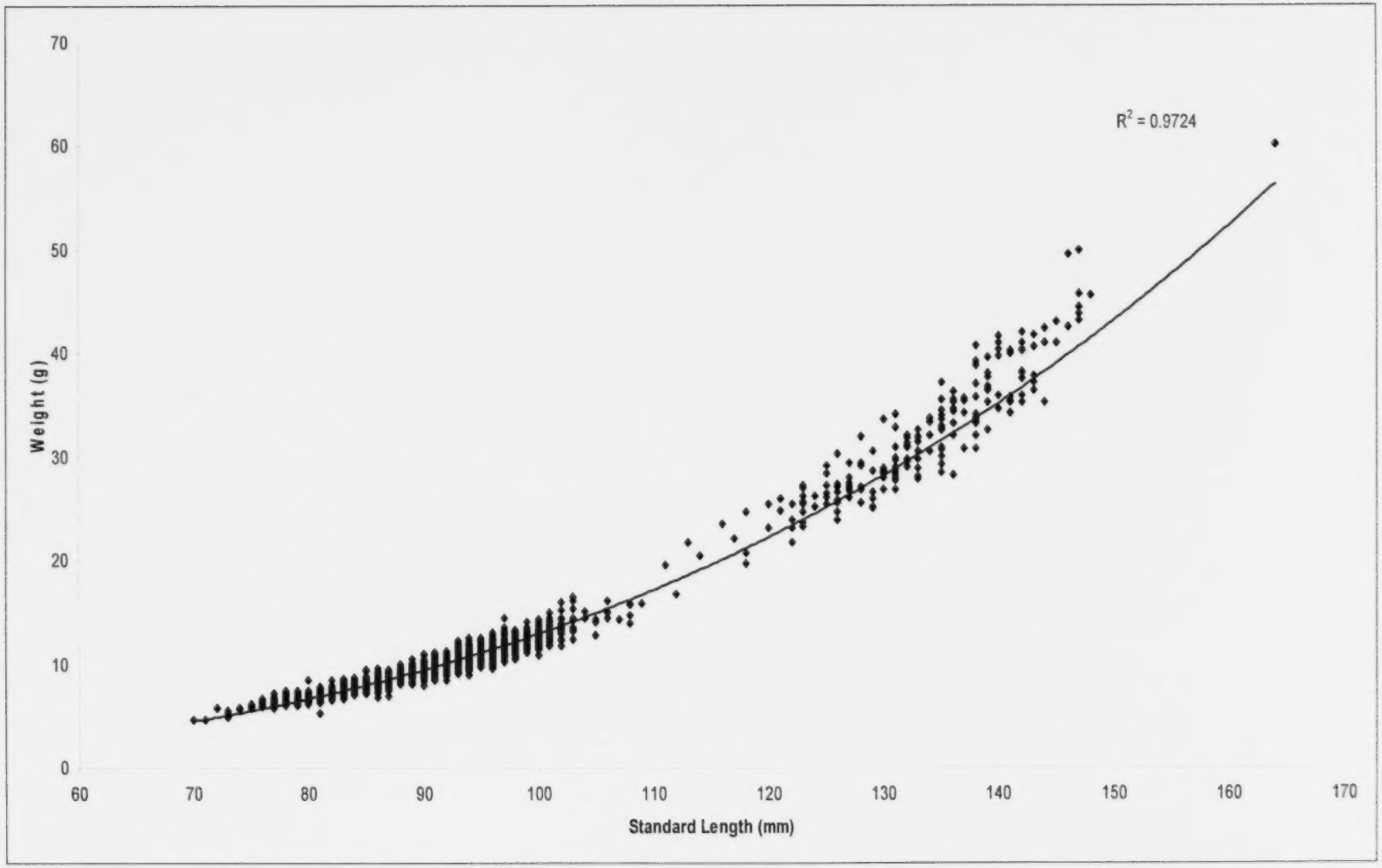


Figure 6. Length-weight relationship for all herring sampled during the 2009 Strait of Georgia juvenile herring survey.

Table 1. Summary of the purse seine set locations from the 2009 Strait of Georgia juvenile herring survey.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2009	9	14	6	1	2040	Trincomali Channel	48.855	123.430
2009	9	14	6	2	2110	Trincomali Channel	48.862	123.423
2009	9	14	6	3	2130	Trincomali Channel	48.867	123.417
2009	9	14	6	4	2150	Trincomali Channel	48.873	123.407
2009	9	14	6	5	2205	Trincomali Channel	48.877	123.407
2009	9	15	2	5	2045	Yellow Point	49.066	123.698
2009	9	15	2	4	2115	Yellow Point	49.060	123.708
2009	9	15	2	3	2145	Yellow Point	49.056	123.722
2009	9	15	2	2	2210	Yellow Point	49.050	123.733
2009	9	15	2	1	2235	Yellow Point	49.042	123.747
2009	9	16	1	1	2030	Clarke Rock	49.224	123.943
2009	9	16	1	2	2055	Clarke Rock	49.233	123.932
2009	9	16	1	3	2115	Clarke Rock	49.237	123.922
2009	9	16	1	4	2140	Clarke Rock	49.237	123.912
2009	9	16	1	5	2200	Clarke Rock	49.238	123.902
2009	9	18	5	1	2020	French Creek	49.348	124.350
2009	9	18	5	2	2040	French Creek	49.353	124.338
2009	9	18	5	3	2100	French Creek	49.358	124.327
2009	9	18	5	4	2115	French Creek	49.362	124.323
2009	9	18	5	5	2140	French Creek	49.366	124.317
2009	9	21	11	1	2035	Secret Cove	49.535	123.977
2009	9	21	11	2	2100	Secret Cove	49.532	123.995
2009	9	21	11	3	2125	Secret Cove	49.528	124.014
2009	9	21	11	4	2155	Secret Cove	49.527	124.040
2009	9	21	11	5	2215	Secret Cove	49.523	124.060
2009	9	22	10	5	2035	Cape Cockburn	49.632	124.278
2009	9	22	10	4	2100	Cape Cockburn	49.642	124.255
2009	9	22	10	3	2125	Cape Cockburn	49.651	124.242
2009	9	22	10	2	2150	Cape Cockburn	49.662	124.218
2009	9	22	10	1	2215	Cape Cockburn	49.700	124.198
2009	9	23	9	1	2030	Atrevida Reef	49.916	124.659
2009	9	23	9	2	2050	Atrevida Reef	49.912	124.673
2009	9	23	9	3	2115	Atrevida Reef	49.909	124.684
2009	9	23	9	4	2135	Atrevida Reef	49.906	124.694
2009	9	23	9	5	2205	Atrevida Reef	49.902	124.707
2009	9	24	8	1	2035	Smelt Bay	50.036	125.000
2009	9	24	8	2	2105	Smelt Bay	50.046	125.016
2009	9	24	8	3	2130	Smelt Bay	50.054	125.030
2009	9	29	4	1	2035	Henry Bay	49.593	124.875
2009	9	29	4	2	2120	Henry Bay	49.601	124.866
2009	9	29	4	3	2150	Henry Bay	49.598	124.856
2009	9	29	4	4	2215	Henry Bay	49.598	124.846
2009	9	29	4	5	2240	Henry Bay	49.602	124.836

Table 1 continued…

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2009	10	1	3	1	2130	Bowser	49.452	124.680
2009	10	1	3	2	2150	Bowser	49.459	124.672
2009	10	1	3	5	2230	Bowser	49.482	124.651
2009	10	1	3	4	2250	Bowser	49.476	124.657
2009	10	1	3	3	2315	Bowser	49.467	124.663

Table 2. Summary of the number and weight by species, transect, and station for 2009 Strait of Georgia juvenile herring survey.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
1	1	Clarke Rock	**Pacific herring age-0+**	220	2.02
			Pacific herring age-1+	50	1.41
			Juvenile pollock	10	0.17
			Flatfish	6	0.26
			Chinook salmon	4	0.25
			Pipefish	4	trace
			Shiner perch	4	0.03
			Squid	2	0.05
			Chum salmon	1	0.05
			Midshipman	1	trace
			Pacific cod	1	0.02
			Sandlance	1	trace
			Sculpin	1	0.10
1	2	Clarke Rock	**Pacific herring age-0+**	362	3.57
			Pacific herring age-1+	2	0.09
			Chum salmon	4	0.28
			Three-spine stickleback	2	trace
1	3	Clarke Rock	**Pacific herring age-0+**	27	0.25
			Chinook salmon	3	0.19
			Chum salmon	2	0.12
			Squid	1	0.14
			Three-spine stickleback	1	trace
1	4	Clarke Rock	**Pacific herring age-0+**	3	0.03
			Chum salmon	4	0.20
			Chinook salmon	1	0.26
			Three-spine stickleback	1	trace
1	5	Clarke Rock	Chum salmon	4	0.24
			Chinook salmon	2	0.20
			Three-spine stickleback	2	trace
			Squid	1	0.21
2	1	Yellow Point	**Pacific herring age-0+**	249	1.83
			Midshipman	12	0.02
2	2	Yellow Point	**Pacific herring age-0+**	1029	8.71
			Midshipman	14	0.10
			Chinook salmon	7	0.38
2	3	Yellow Point	**Pacific herring age-0+**	595	4.60
2	4	Yellow Point	**Pacific herring age-0+**	3198	23.70

* Weights ≤9 g referred to as trace

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
2	5	Yellow Point	**Pacific herring age-0+**	46	0.34
			Chinook salmon	4	0.07
			Sandlance	2	0.01
3	1	Bowser	Chinook salmon	11	0.78
			Sandlance	10	0.06
			Gunnel	3	0.01
			Chum salmon	1	0.08
			Squid	1	0.24
3	2	Bowser	**Pacific herring age-0+**	2	0.02
			Chinook salmon	3	0.17
			Gunnel	2	0.01
			Chum salmon	1	0.08
3	3	Bowser	**Pacific herring age-0+**	10	0.12
			Chum salmon	5	0.34
			Chinook salmon	1	0.25
			Coho salmon	1	0.20
3	4	Bowser	**Pacific herring age-0+**	2250	26.92
			Pacific herring age-1+	9	0.15
			Chum salmon	9	0.75
3	5	Bowser	**Pacific herring age-0+**	14	0.16
			Chum salmon	3	0.22
			Chinook salmon	1	0.10
			Sandlance	1	trace
			Squid	1	0.09
4	1	Henry Bay	**Pacific herring age-0+**	216	2.51
			Northern Anchovy	20	0.06
			Midshipman	10	0.01
			Juvenile pollock	8	0.08
			Sculpin	2	0.02
4	2	Henry Bay	**Pacific herring age-0+**	364	4.01
			Midshipman	32	0.05
4	3	Henry Bay	**Pacific herring age-0+**	354	3.88
			Midshipman	16	0.03
			Chinook salmon	2	0.30
			Sculpin	2	0.08
4	4	Henry Bay	**Pacific herring age-0+**	2384	26.04

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
4	5	Henry Bay	**Pacific herring age-0+**	1218	13.27
			Pacific herring age-1+	6	0.15
			Midshipman	132	0.18
			Juvenile pollock	12	0.12
			Gunnel	6	0.02
			Snake prickleback	6	0.06
			Squid	6	0.29
			Three-spine stickleback	6	0.01
5	1	French Creek	**Pacific herring age-0+**	32	0.31
			Pacific herring age-1+	9	0.23
			Chinook salmon	7	0.46
			Flatfish	7	0.12
			Chum salmon	4	0.24
			Coho salmon	3	0.14
			Sculpin	2	0.36
			Pipefish	1	trace
			Shiner perch	1	0.01
5	2	French Creek	Chinook salmon	1	0.20
			Chum salmon	1	0.20
			Coho salmon	1	0.20
5	3	French Creek	***NO CATCH***		
5	4	French Creek	Coho salmon	12	3.05
5	5	French Creek	Coho salmon	5	1.48
			Chinook salmon	1	0.10
6	1	Trincomali Channel	**Pacific herring age-0+**	39	0.25
			Chum salmon	3	0.11
			Sculpin	2	0.19
6	2	Trincomali Channel	**Pacific herring age-0+**	49	0.36
			Sandlance	2	trace
			Chinook salmon	1	0.03
6	3	Trincomali Channel	**Pacific herring age-0+**	13	0.10
			Midshipman	1	0.06
6	4	Trincomali Channel	**Pacific herring age-0+**	10	0.07
			Chum salmon	3	0.14
			Sandlance	1	trace

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
6	5	Trincomali Channel	**Pacific herring age-0+**	362	2.53
			Chum salmon	2	0.06
			Midshipman	2	0.06
			Juvenile pollock	2	0.17
			Pacific sardine	1	0.19
8	1	Smelt Bay	**Pacific herring age-0+**	1	0.01
			Chum salmon	31	1.79
			Pipefish	2	trace
			Chinook salmon	1	0.04
			Snake prickleback	1	0.02
8	2	Smelt Bay	**Pacific herring age-0+**	56	0.49
			Chum salmon	35	2.13
			Chinook salmon	3	0.23
			Three-spine stickleback	2	trace
			Midshipman	1	0.01
8	3	Smelt Bay	**Pacific herring age-0+**	2	0.02
			Three-spine stickleback	2	trace
			Chinook salmon	1	0.09
			Snake prickleback	1	trace
			Sandlance	1	trace
9	1	Atrevida Reef	**Pacific herring age-2+**	1	0.06
			Pink salmon	1	0.03
9	2	Atrevida Reef	**Pacific herring age-0+**	1212	11.55
			Juvenile pollock	12	0.10
			Northern Anchovy	6	0.10
9	3	Atrevida Reef	**Pacific herring age-0+**	1506	15.38
			Pacific herring age-1+	60	1.95
			Juvenile pollock	108	1.52
			Juvenile hake	12	0.07
9	4	Atrevida Reef	**Pacific herring age-0+**	1872	18.98
			Pacific herring age-1+	630	21.84
9	5	Atrevida Reef	**Pacific herring age-0+**	2070	20.41
			Pacific herring age-1+	318	16.05

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
10	1	Cape Cockburn	**Pacific herring age-0+**	76	0.77
			Pacific herring age-1+	2	0.07
			Three-spine stickleback	3	trace
			Northern Anchovy	1	trace
			Chinook salmon	1	0.04
			Chum salmon	1	0.06
			Pipefish	1	trace
			Juvenile pollock	1	0.02
			Juvenile rockfish	1	trace
			Sandlance	1	trace
10	2	Cape Cockburn	**Pacific herring age-0+**	6	0.06
			Juvenile hake	13	0.05
			Chum salmon	3	0.20
			Pipefish	1	trace
10	3	Cape Cockburn	**Pacific herring age-0+**	1	0.01
			Juvenile hake	32	0.08
			Chum salmon	1	0.08
10	4	Cape Cockburn	**Pacific herring age-0+**	10	0.12
			Juvenile hake	10	0.02
			Chum salmon	3	0.17
10	5	Cape Cockburn	**Pacific herring age-0+**	197	2.18
			Midshipman	48	0.04
			Chinook salmon	3	0.13
			Chum salmon	1	0.05
			Juvenile pollock	1	0.01
11	1	Secret Cove	**Pacific herring age-0+**	4473	43.54
			Pacific herring age-1+	21	0.53
11	2	Secret Cove	**Pacific herring age-0+**	992	10.84
			Juvenile pollock	24	0.22
			Juvenile hake	8	0.04
			Chinook salmon	4	0.67
11	3	Secret Cove	**Pacific herring age-0+**	1116	12.66
			Juvenile pollock	54	0.44
11	4	Secret Cove	**Pacific herring age-0+**	9	0.11
			Chum salmon	4	0.28
11	5	Secret Cove	Chum salmon	2	0.10

Table 3. Percent occurrence by species in purse seine sets for the Strait of Georgia juvenile herring survey in 2009.

Species Caught		Percent Occurrence
Common Name*	**Scientific Name**	**2009**
Pacifc Herring Age-0+	*Clupea pallasi* young-of-the-year	83.3
Pacifc Herring Age-1+	*Clupea pallasi* in first year	20.8
Pacifc Herring Age-2+	*Clupea pallasi* in second year or more	2.1
Chinook salmon	*Oncorhyncus tshawytscha*	43.8
Chum salmon	*Oncorhyncus keta*	50.0
Midshipman	*Porichthys notatus*	22.9
Juvenile Pollock	*Theragra chalcogramma*	20.8
Three-spine Stickleback	*Gasterosteus aculeatus*	16.7
Sandlance	*Ammodytes hexapterus*	16.7
Coho salmon	*Oncorhyncus kisutch*	10.4
Juvenile Pacific Hake	*Merluccius productus*	10.4
Pipefish	*Syngnathus griseolineatus*	10.4
Sculpin	*Leptocottus armatus*	10.4
Northern Anchovy	*Engraulis mordax mordax*	6.3
Gunnel	*Apodichthys flavidus* or *Pholis laeta*	6.3
Snake Prickleback	*Lumpenus sagitta*	6.3
Shiner Perch	*Cymatogaster aggregata*	4.2
Flatfish	*Parophyrus vetulus, Lepidopsetta bilineata, Platichthys stellatus,* or *Citharichthys stigmaens*	4.2
Pacific cod	*Gadus macrocephalus*	2.1
Juvenile Rockfish	*Sebastes sp.*	2.1
Pink salmon	*Oncorhyncus gorbuscha*	2.1
Pacific Sardine	*Sardinops sagax*	2.1
No Catch		2.1

* Squid and jellyfish occurrence is not included due to the large quantities usually encountered and the inability to correctly quantify.

Table 4. Summary of the number of fish sampled, range of length, mean length, range of weight, mean weight, and standard deviations for two herring age classes. Total catch in numbers (N) and weight (Wt) of all herring by transect for 2009.

Age-0+		Length (mm)				Weight (g)				
Location Name	Transect	Sampled	Range	Mean	SD	Range	Mean	SD	N	Wt (Kg)
Clarke Rock	1	230	79-103	91	4.51	6.54-14.42	9.48	1.47	612	5.87
Yellow Point	2	406	72-106	83	4.55	5.54-14.40	7.77	1.14	5117	39.18
Bowser	3	125	88-107	98	3.38	9.13-16.12	11.91	1.17	2276	27.23
Henry Bay	4	508	80-108	95	3.56	6.81-16.08	11.09	1.18	4536	49.71
French Creek	5	32	79-101	91	5.81	6.91-12.65	9.12	1.69	32	0.29
Trincomali	6	211	70-109	82	4.63	4.60-15.76	7.02	1.17	473	3.32
Smelt Bay	8	59	79-97	88	4.09	5.95-11.14	8.68	1.03	59	0.51
Atrevida Reef	9	400	82-102	92	3.44	7.58-14.07	9.93	1.04	6660	66.31
Cape Cockburn	10	193	73-106	95	5.14	5.22-16.43	10.77	1.68	290	3.15
Secret Cove	11	309	76-108	94	4.58	5.99-15.95	10.71	1.56	6590	67.16
All locations		2474	70-109	91	6.47	4.60-16.43	9.75	1.94	26645	262.73

Age-1+		Length (mm)				Weight (g)				
Location Name	Transect	Sampled	Range	Mean	SD	Range	Mean	SD	N	Wt (Kg)
Clarke Rock	1	51	114-145	129	5.83	20.38-43.02	28.47	4.01	52	1.49
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	1	112	112		16.65	16.65		9	0.15
Henry Bay	4	1	121	121		24.71	24.71		6	0.15
French Creek	5	9	111-138	125	9.28	19.47-33.47	25.89	4.79	9	0.23
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	-	-	-	-	-	-	-	-	-
Atrevida Reef	9	133	113-148	135	7.12	21.67-49.52	33.38	5.79	1008	39.84
Cape Cockburn	10	2	118-147	133	20.51	20.70-49.83	35.27	20.6	2	0.07
Secret Cove	11	1	120	120		25.33	25.33		21	0.53
All locations		198	111-148	133	7.63	16.65-49.83	31.69	6.08	1107	42.47

Table 5. Grouping of organisms, by phylum with abbreviations from the 2009 plankton tows from the Strait of Georgia juvenile herring survey.

Coelenterata	
COEL	Medusae - *Aequorea victoria*
SIPH	Siphonophores
Ctenophora	
CTEN	Ctenophores
Annelida	
POLY	Polychaetes
Mollusca	
GAST	Prosobranch gastropods
PELE	Pelecypods
LHEL	*Limacina helicina*
Arthropoda	
AMPH	Amphipods
BARN	Barnacle, unknown stage
CAMA	*Camacea sp.*
CLAD	Cladocerans; *Podon sp.* and *Evadne sp.*
CNAU	Unidentified copepod nauplii
COPE	Copepods (see Table 6 for list of species)
CRAM	Crab megalopea, including porcillinadea
CRAZ	Crab zoea, including porcillinadea
EUPA	Adult euphausiids; mainly *Euphausia pacifica*
EUPL	Larval euphausiids; mainly *Euphausia pacifica*
MYSI	Mysids
OSTR	Ostracods
SHRI	Shrimp zoea
Ectoprocta	
ECTO	Ectoprocts; mainly *Membranipora sp.* larvae
Chaetognatha	
CHAE	Chaetognaths; mainly *Sagitta sp.*
Chordata	
LARV	Larvaceans; mainly *Oikopleura sp.*
FISHL	Teleost larvae
Miscellaneous	
EGGS	Unidentified eggs; either euphausiid or teleost

Table 6. Abbreviations for calanoid and cyclopoid copepods identified in 2009 plankton samples from the Strait of Georgia juvenile herring survey.

Calanoid copepods	
ALON	*Acartia longiremis*
CABD	*Centropages abdominales*
CALA	*Calanus sp.*
CMAR	*Calanus marshalle*
CPAC	*Calanus pacificus*
EBUN	*Eucalanus bungii*
ELON	*Epilabidocera longipedata*
METR	*Metridia sp.*
MPAC	*Metridia pacifica*
OBOR	*Oncaea borealis*
PPAR	*Paracalanus parvus*
PSEU	*Pseudocalanus sp.*
TDIS	*Tortanus discaudatus*
UCAL	Unidentified or mixed juvenile calanoids
Cyclopoid copepods	
CANG	*Corycaeus anglicus*
OATL	*Oithona atlantica*
OITH	*Oithona sp.*
OSIM	*Oithona similis*

Table 7. Number of zooplankton per m^3 of water by set in samples from the 2009 Strait of Georgia juvenile herring survey. Species codes as shown in table 6.

Location	Tran	Stn	Volume (m^3)	ALON	AMPH	BARN	CABD	CALA	CAMA	CANG	CHAE	CLAD
Clarke Rock	1	1	13.867	0.6	0.6	90.6	-	2.3	-	17.3	-	14.4
		3	17.565	0.5	0.7	32.8	-	-	-	15.9	0.3	6.4
Yellow Point	2	1	14.097	-	1.3	28.7	-	98.7	-	39.7	-	20.4
		4	16.154	2.0	0.2	17.8	-	145.0	-	33.7	-	15.8
Bowser	3	1	5.640	-	-	272.5	-	-	-	-	-	2303.6
		4	15.747	-	0.2	-	-	139.4	-	2.0	0.1	-
Henry Bay	4	1	4.052	-	4.2	406.8	-	-	-	-	-	264.6
		3	2.758	-	1.5	1125.5	23.2	-	-	29.0	-	440.9
French Creek	5	1	13.449	-	1.9	0.6	-	8.0	-	4.2	-	103.5
		3	16.129	-	2.1	-	-	10.0	-	7.4	-	1.5
Trincomali	6	1	13.198	9.7	0.5	419.5	-	6.4	-	19.4	0.1	77.6
		3	14.613	10.9	13.5	302.2	-	2.2	-	26.3	2.2	35.0
Smelt Bay	8	1	14.397	-	0.3	83.4	-	5.8	-	28.9	-	20.0
		2	13.271	-	-	50.6	-	63.4	-	183.3	-	4.8
Atrevida Reef	9	1	13.418	-	2.5	6.0	1.2	0.6	0.1	14.3	-	-
		3	11.296	-	1.4	2.8	-	3.1	-	18.4	-	-
Cape Cockburn	10	3	17.273	-	6.6	-	-	5.7	-	67.6	0.2	-
		5	17.155	-	3.7	3.7	5.6	22.4	-	7.5	-	-
Secret Cove	11	1	14.998	-	-	26.1	10.3	15.3	0.1	51.2	-	10.7
		3	15.221	-	0.7	-	-	30.5	-	41.0	-	-

Table 7 continued...

Location	Tran	Stn	CMAR	CNAU	COEL	CPAC	CRAM	CRAZ	CTEN	EBUN	ECTO	EGGS	ELON
Clarke Rock	1	1	-	1.2	0.6	-	0.6	9.6	-	-	4.0	2.9	-
		3	0.1	-	0.2	0.1	0.1	1.0	-	0.1	-	-	-
Yellow Point	2	1	-	10.2	2.1	0.6	-	0.4	-	-	1.1	55.8	-
		4	-	-	2.8	5.8	0.5	0.6	-	-	-	-	-
Bowser	3	1	-	-	0.2	-	0.7	16.0	0.2	-	-	-	-
		4	-	-	0.1	27.9	0.1	-	-	0.5	-	-	-
Henry Bay	4	1	-	-	17.5	-	0.2	9.9	-	-	-	-	-
		3	-	-	5.4	0.7	0.4	8.3	-	-	34.8	-	-
French Creek	5	1	-	-	0.1	0.2	-	0.7	-	0.1	-	-	-
		3	-	-	0.1	0.3	0.1	0.1	-	-	-	-	-
Trincomali	6	1	-	-	0.2	0.2	1.6	2.0	0.1	-	-	-	0.2
		3	-	-	0.7	-	0.1	0.4	-	-	-	-	-
Smelt Bay	8	1	-	-	8.6	-	0.3	5.0	1.4	-	-	-	-
		2	-	-	0.6	6.9	0.3	8.7	8.7	-	-	-	-
Atrevida Reef	9	1	-	2.4	0.7	-	-	1.3	-	-	-	-	-
		3	-	1.4	0.1	0.1	0.1	0.1	-	-	165.7	-	0.1
Cape Cockburn	10	3	-	-	-	2.1	-	-	0.1	-	-	-	-
		5	-	-	-	3.3	-	-	-	-	-	-	-
Secret Cove	11	1	-	-	0.4	-	0.1	19.7	-	-	6.4	12.9	-
		3	-	-	0.2	0.5	0.1	0.1	-	-	-	12.6	-

Table 7 continued...

Location	Tran	Stn	EUPA	EUPL	FISHL	GAST	LARV	LHEL	METR	MPAC	MYSI	OATL	OBOR
Clarke Rock	1	1	-	-	-	0.6	36.3	-	-	1.2	-	-	0.6
		3	-	-	-	-	5.5	-	4.2	-	-	8.7	-
Yellow Point	2	1	-	5.7	-	-	10.2	-	-	-	0.4	-	-
		4	0.1	-	0.1	-	-	-	-	-	-	-	-
Bowser	3	1	-	11.3	-	283.7	385.8	-	-	-	1.8	-	11.3
		4	1.0	0.5	-	-	14.2	0.4	-	6.6	0.1	-	-
Henry Bay	4	1	-	0.2	-	-	47.4	-	-	-	6.2	-	-
		3	-	-	-	81.2	249.5	-	-	-	-	-	-
French Creek	5	1	-	-	-	0.6	0.6	-	-	-	5.0	16.7	-
		3	-	-	-	2.5	-	-	1.9	0.1	0.1	4.0	-
Trincomali	6	1	-	0.2	-	-	177.0	-	-	0.1	0.2	-	-
		3	-	-	-	15.3	102.9	-	-	-	-	-	-
Smelt Bay	8	1	-	-	0.3	82.2	75.6	-	-	-	-	-	-
		2	0.3	-	-	38.6	82.0	-	-	-	-	-	-
Atrevida Reef	9	1	-	-	-	16.7	223.0	-	-	-	0.3	23.8	-
		3	4.7	-	-	9.9	-	-	-	-	-	-	-
Cape Cockburn	10	3	8.0	0.3	-	-	16.7	-	-	-	-	38.0	-
		5	78.3	-	-	18.7	14.9	-	-	-	-	-	3.7
Secret Cove	11	1	-	-	-	12.8	189.9	-	-	-	-	10.7	-
		3	-	-	-	8.4	45.2	-	-	-	-	28.4	1.1

Table 7 continued…

Location	Tran	Stn	OITH	OSIM	OSTR	PELE	POLY	PPAR	PSEU	SHRI	SIPH	TDIS	UCAL
Clarke Rock	1	1	-	33.5	-	-	2.9	28.8	10.4	14.2	-	-	0.1
		3	-	5.5	-	-	0.5	9.3	7.0	0.1	-	-	0.1
Yellow Point	2	1	-	11.4	-	-	-	22.5	8.9	1.8	0.5	4.5	-
		4	-	-	-	-	2.0	43.0	-	1.1	0.2	-	-
Bowser	3	1	-	158.9	-	-	-	683.2	-	18.6	0.5	133.9	-
		4	-	2.0	0.1	-	-	42.7	77.3	0.3	-	-	-
Henry Bay	4	1	-	19.7	-	3.9	3.9	3.9	6.7	5.4	1.0	96.0	0.2
		3	17.4	58.0	-	17.4	17.4	266.9	-	11.6	0.7	388.7	0.4
French Creek	5	1	-	12.5	-	-	-	14.7	3.0	0.4	-	3.0	-
		3	-	57.5	-	-	-	7.9	25.1	0.3	0.1	-	-
Trincomali	6	1	14.5	-	0.5	2.4	36.4	115.4	2.4	5.2	-	-	-
		3	8.8	-	-	-	0.1	43.8	6.6	7.2	-	-	-
Smelt Bay	8	1	-	11.1	-	1.1	10.0	73.1	-	40.6	117.0	-	-
		2	-	16.9	-	-	19.3	61.0	-	12.7	108.5	-	-
Atrevida Reef	9	1	9.5	95.4	-	-	-	44.7	-	1.8	-	-	-
		3	-	69.4	-	-	-	76.2	4.2	1.6	1.9	-	0.2
Cape Cockburn	10	3	-	225.1	-	-	0.1	188.4	35.5	0.2	-	-	-
		5	-	106.3	-	1.9	-	203.3	29.8	-	-	-	-
Secret Cove	11	1	-	64.0	-	-	2.1	81.1	-	1.7	0.2	-	-
		3	11.6	84.1	-	-	-	56.6	26.5	0.3	0.1	-	-